MICROSTRUCTURES IN THE CARBONATE GLOBULES OF MARTIAN METEORITE ALH84001: PRELIMINARY RESULTS OF A HIGH RESOLUTION SEM STUDY. F. Westall[1], P. Gobbi[2], D. Gerneke[3], and G. Mazzotti[2], [1]University of Bologna, [2]Department of Human Anatomy, University of Bologna, Bologna, Italy, [3]Electron Microscope Unit, University of Cape Town, Rondebosch, South Africa.

Fe- and Mg-zoned carbonate globules in the fractures permeating the orthopyroxene meteorite ALH84001, of presumed Martian origin, have excited interest because of the possibility (1) that they represent water-born deposits [1,2,3], and (2) that they may contain the fossil remains of life [2]. The ca. 3.6 Ga-old carbonate globules, occurring in a host rock dated at 4.5 Ga, are similar in age to some of the earliest sediments on Earth in which there are signs of life [4,5,6,7]. This similarity and the apparently warmer, wetter conditions [8], capable of supporting life, during the first millennium of Martian history have stimulated attempts to increase our knowledge of early terrestrial life and how it is preserved, and to compare the terrestrial data to what is available at present from Mars in the hopes of confirming the preliminary interpretations of life in ALH84001.

McKay et al. [2] describe ovoid to elongated structures 20-100 nm long which they interpreted as possible nanobacteria (sensu Folk, [9]). Subsequent studies have demonstrated that some of the original structures described by McKay et al [2], but not all, are mineralogical in origin [10,11]. Furthermore, the debate concerning the existence and geological importance of nanobacteria has only just started, given the fact that this is a brand new field of research [9,12,13].

We are in the process of studying a fragment of ALH84001, containing a number of carbonate globules on a fracture surface, using high resolution SEM (JEOL 849 FEI-SEM and LEO STEROSCAN 440) to document microstructures occurring in the carbonate globules with the aim of detecting structures which would resemble fossil life forms. We observed the sample uncoated initially and then with a ca. 2.5 nm-thick C-Pt coat.

Blocky grains of Fe-carbonate in the carbonate globules, some showing evidence of dissolution, are characterised by fine, crystallographically-determined laminations. A number of these grains contain "floating" inclusions (i.e.. not in contact with each other) which may be rounded, subrounded to angular (20-100 nm in size) or elongated (up to 130 nm in length and < 10 nm in width). Some of the inclusions are banded whereas others appear to be cleaved. The more elongated inclusions are aligned parallel to the crystallographic laminations (similar to the structures described by Bradley et al., [10]), whereas the other inclusions are disoriented. These structures form part of the mineral framework as they can be seen in freshly cleaved fractures in the blocky carbonate. We do not know the composition of the inclusions at present. Some inclusions occur in the Mg-carbonate but their occurrence in this material is sparser.

Many internal fracture surfaces and some corrosion surfaces within the carbonate globules are coated with an amorphous material composed of tiny 50-100 nm spherules in contact with each other and cemented by a smooth material. The amorphous material is porous and presents a reticulated texture. EDS analysis shows that it consists of silica.

Subangular to angular chromite fragments embedded in the carbonate globules also contain irregularly-shaped inclusions <5 to 200 nm in size and a few of them contain 1 µm rounded cores of material of a different composition (with a similar backscatter signal to the Fe-carbonate). These inclusions are also found in the chromite grains within the orthopyroxene host rock.

Some of the "floating" inclusions in the blocky Fe-carbonate are clearly mineralogical in origin: the elongated structures parallel to the crystallographic lamellae are obviously lamellae edges (cf. Bradley et al . [10]). The rounded to subangular disoriented inclusions, however, have a different origin. There are a number of possible explanations. (1) They may represent ground up particles of the orthopyroxene host rock, produced during the first impact shock which caused the fracturing of the rock. They would then have been deposited by the carbonate-bearing fluid. The presence of broken chromite grains containing identical inclusions in both the orthopyroxene and the carbonate globules is in favour of this hypothesis. (2) Alternatively, they may have been introduced externally by an externally-originating, carbonate-bearing fluid. Analysis of the composition of the inclusions will aid their interpretation.

The amorphous silica film postdates secondary fracturing of the carbonate globules and a dissolution event (cf. Valley et al., [14]). This deposit is similar to amorphous silica in some Early

Archean sediments containing fossil bacteria which were flushed by low-temperature, silica-rich, hydrothermal fluids. The analogy is that hydrothermal fluids flushed the orthopyroxene while the rock was on the surface of Mars, thus supporting previous suggestions of hydrothermal influences [1,15,16,3].

Our preliminary observations are not conclusive as to the presence of structures of biological origin in the carbonate globules of ALH84001. There are microstructures of definite mineralogical origin, and others of, as yet unknown (but possibly mineralogical) origin. The support for hydrothermal flushing of the rock should stimulate further searches, given the close association of fossil terrestrial bacteria of similar age to the carbonate globules with hydrothermal sediments [7,17].

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